Modeling Beach Morphology Changes Coupled to Incident Wave Climate and Low Frequency Currents

James T. Kirby
Center for Applied Coastal Research
University of Delaware
Newark, DE 19716
phone: (302) 831-2438   fax: (302) 831-1228   email: kirby@udel.edu
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LONG-TERM GOAL

My longterm goal is to develop physics-based models to predict nearshore morphology changes, and to test the models against available field data.

OBJECTIVES

The objectives of the present project are to:

(1) Incorporate a sediment transport and bed morphology capability in the wave-induced circulation model of Özkan-Haller and Kirby (1997, 1999)
(2) Use the resulting model to study the growth to finite amplitude of bottom perturbations on initially longshore-uniform planar or barred beaches
(3) Use the model to investigate the evolution of three-dimensional bed features under specific wave conditions, in comparison to ARGUS video results for the Duck FRF site.
(4) Begin the development of an instantaneous sediment transport capability (on a wave by wave basis) in the Boussinesq model of Wei et al (1995).

APPROACH

Our approach is to use a robust numerical code for the modeling of 2D or quasi-3D wave-driven nearshore circulation as the basis for computing the local wave-averaged sediment transport rate and the resulting evolution of nearshore morphology. The model results will be limited in accuracy by both the accuracy of input wave information and by the accuracy of the local sediment transport model. By using data from the FRF ARGUS station and related wave information from in situ pressure gage arrays, we seek to determine whether the model will reproduce qualitative shifts in overall bed geometry which have been observed to correlate with shifts in wave conditions (Lippman and Holman, 1990).

WORK COMPLETED

In the six months since the project start, we have pursued work on the extension of the hydrodynamic code to include a realistic coastal transport model. Initially, we have coupled a simpler transport model suitable for riverine situations to the hydrodynamic code. We have begun an evaluation of the long-term behavior of various unstable bedform patterns, whose linear stability analyses have been

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described in the literature (Falqués et al, 1996; Schielen et al, 1993). Work on extending the model to incorporate a Bagnold-Bailard-Bowen type model for wave-induced transport is underway.

RESULTS

Results to date are limited to calculations based on sediment transport modeling for slowly varying unidirectional flows, as pursued in Falqués et al. (1996) and Schielen et al (1993). Figure 1 illustrates one longshore wavelength of an initial perturbation corresponding to the unstable perturbations described by Falqués et al. The perturbation undergoes a marked distortion in form as it evolves, finally settling into a nearly longshore uniform shore-parallel bar. The final configuration basically indicates a steepening of the beach and flattening of the mid-surfzone, with deposition of the eroded material at the outer extreme of the surfzone. Note that there are no primarily cross-shore oriented sediment transport mechanisms at work here, since wave effects are left out of the transport calculation and undertow is not incorporated in the hydrodynamics. The resulting cross-shore transport is related to dispersive mixing associated with shear wave fluctuations, which will also play a role in more realistic calculations.

IMPACT/APPLICATION

This work is intended to provide a process-based model for predicting nearshore large scale bedform evolution over day to week time scales, as a first step to bridging the gap between short-time physical predictions and longer time (annual and longer) predictions based on parameterized physics. This gap is still immense, and will only be closed with (1) the advent of both faster computers and with (2) the ability to assess the accuracy of local sediment transport formulations applied over reasonably long time scales. We are mainly concerned with the second aspect of this problem.

TRANSITIONS

The work on morphology evolution conducted here will carry over directly into the seabed module work in the NOPP nearshore project. Tuba Özkan-Haller is working very closely with us, with model extensions and developments being shared by all investigators.

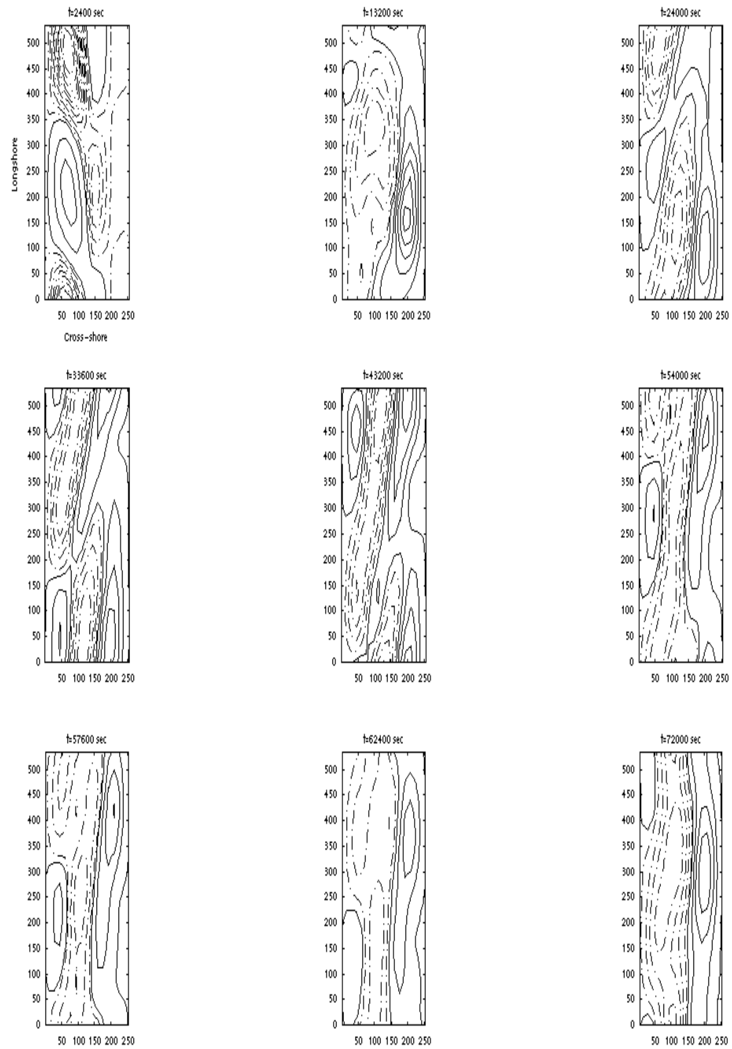

Figure 1: Nine sample images of the growth of initial bed perturbations. Contours are of bed elevation change, with solid contours indicating accretion and dashed contours indicating erosion.

RELATED PROJECTS

(1) N00014-99-1-0490 "Prediction of the Low Frequency Wave Field on Open Coastal Beaches", H. Tuba Özkan-Haller, Univ. Mich.   Tuba is directly involved in this work, and will be in principal charge of transitioning results on the morphology model here to NOPP models. We are also using her work on extensions to the wave driver portion of the hydrodynamic code.

(2) N00014-99-1-1051 (NOPP) "Development and Verification of a Comprehensive Community Model for Physical Processes in the Nearshore Ocean", James T. Kirby et al, Univ. of Del. The work

on morphology evolution done here will provide a foundation for work in this area in the NOPP project.

(3) N00014-00-?-???? (new start) "Alongshore Propagating Waves in the Nearshore Region", U. Putrevu (NWRA) and James T. Kirby (U. Del.). The code developed here would be used to help in assessing the long-term behavior of hydrodynamic models of low frequency motion based on a modal decomposition of the linearized low-frequency sea state.

REFERENCES

Falqués, A., Montoto, A. and Iranzo, V., 1996, "Bed-flow instability of the longshore current", Continental *Shelf Research*, 16, 1927-1964.

Lippman, T. C. and Holman, R. A., 1990, "The spatial and temporal variability of sand bar morphology", *J. Geophys. Res*., **95**, 11,575-11,590.

Özkan-Haller, H. T. and Kirby, J. T., 1997, "A Fourier-Chebyshev collocation method for the shallow wate equations including shoreline runup", *Applied Ocean Research*, **19**, 21-34.

Özkan-Haller, H. T. and Kirby, J. T., 1999, "Nonlinear evolution of shear instabilities of the longshore current: A comparison of observations and computations", *Journal of Geophysical Research*, **104**, November.

Schielen, R., Doelman, A. and de Swart, H. E., 1993, "On the nonlinear dynamics of free bars in straight channels", *J. Fluid Mech*., **252**, 325-356.

Wei, G., Kirby, J. T., Grilli, S. T. and Subramanya, R., 1995, "A fully nonlinear Boussinesq model for surface waves. I. Highly nonlinear, unsteady waves", *Journal of Fluid Mechanics*, **294**, 71-92.

PUBLICATIONS

Güngördü, Ö, Kirby, J. T. and Özkan-Haller, H. T., 2000, "Long time evolution of coupled hydrodynamic and seabed instabilities", accepted for *27th Intl. Conf. Coastal Engrng*., Sydney.